MERCURY: THERMAL MODELING AND DATA COMPARISON. J. P. Emery, *Department of Planetary Science, University of Arizona, Tucson AZ 85721, USA, josh@lpl.arizona.edu*, J. E. Colwell, *Department of Astrophysical, Planetary and Atmospheric Sciences, University of Colorado, Boulder CO 80309, USA*, A. L. Sprague, *Department of Planetary Science, University of Arizona, Tucson AZ 85721, USA*.

1 Introduction

We have developed a numerical model which simulates the thermal emission from the surface of slowly rotating, airless bodies, such as Mercury. The effects of surface roughness are incorporated in a manner similar to that used by Hansen (1977), Spencer (1990), and Colwell et.al. (1990).

2 Model Description

In our model, an energy balance equation is solved for temperature inside spherical section craters which are distributed uniformly across the surface and for smooth surface elements located between these craters. From these temperatures we can create a disk-integrated infrared thermal emission model spectrum as well as a two dimensional model image at each wavelength with any desired amount of resolution across the disk of the planet. The craters used to simulate surface roughness are not to be correlated with any real surface features, they are simply a tool used for modelling a rough surface. The energy balance equation which is solved for temperature within each of these craters includes heating by direct sunlight, by sunlight multiply scattered by the crater walls, and by reabsorption of thermal radiation emitted by other parts of the crater. Shadowing and visibility of elements within the crater are also included.

Surface roughness is parameterized by an RMS surface slope (s) which is calculated by averaging the square of the angular slope of each surface element (including the smooth surface elements between craters) weighted by its projection on a horizontal surface ($s^2 = < \theta^2 \cos\theta >$). The model surface roughness is therefore a measure of both the half-angle of the craters (the angle between the centerline and the edge of the spherical section crater, i.e. a hemispherical crater has a half-angle of 90^o) and the fraction of the surface they cover, rather than either factor independently.

3 Discussion

Our model produces disk-integrated thermal emission spectra which show the effects of thermal beaming expected for a rough surface [2]. A rough surface emits an increased amount of flux in the zero phase direction relative to a smooth surface. Consequently there is less flux emitted at large phase angles relative to a smooth surface (Fig. 1). The thermal emission spectrum produced by a rough surface peaks at a slightly different wavelength than a smooth surface thermal emission spectrum. This effect is also phase angle dependent. At small phase angles the rough surface spectrum peaks at a shorter wavelength than the smooth surface spectrum, and at large phase angles the rough surface spectrum peaks at a longer wavelength than the smooth surface spectrum (see Figs. 2 and 3).

This model also has the ability to produce two dimensional model images of thermal flux. When thermal flux observation become available which have some amount of resolution across the disk of the planet, this model can be used to analyze the spectra of individual parts of the planet.

Our model is particularly useful for analysis of thermal infrared data from the planet Mercury. An important step in the proper interpretation of mid-infrared spectroscopic measurements is to account for the thermal continuum. Figures 2 and 3 show that our rough surface model closely approximates the Mercurian flux at two observational geometries and is an improvement over a smooth surface, radiative equilibrium model.

4 References

[1] Hansen, O.L., 1977, Icarus 31, 456-482 [2] Spencer, J.R., 1990, Icarus 83, 27-38 [3] Colwell, J.E., B.M. Jakosky, B.J. Sandor, S.A. Stern, 1990, Icarus, 85, 206-215 [4] Sprague, A.L., F.C. Witteborn, R.W.H. Kozlowski, D.H. Wooden, 1996, LPSC XXVII Abstracts, 1251-1252

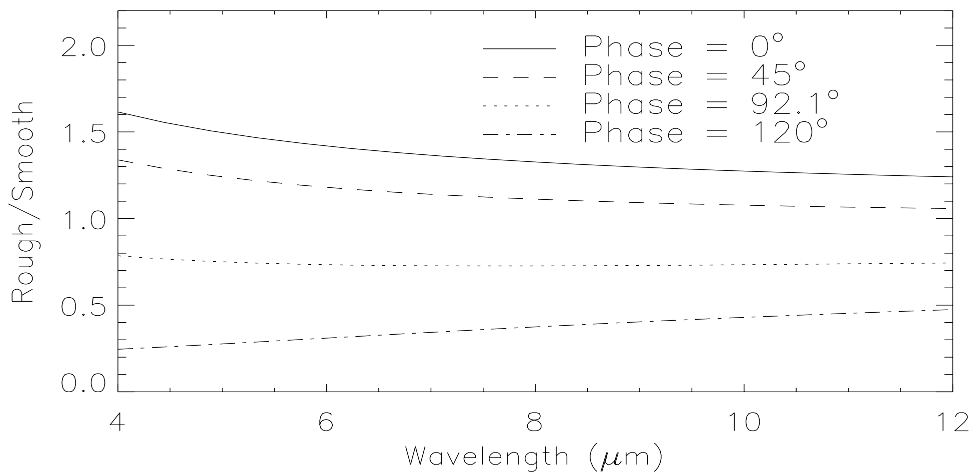
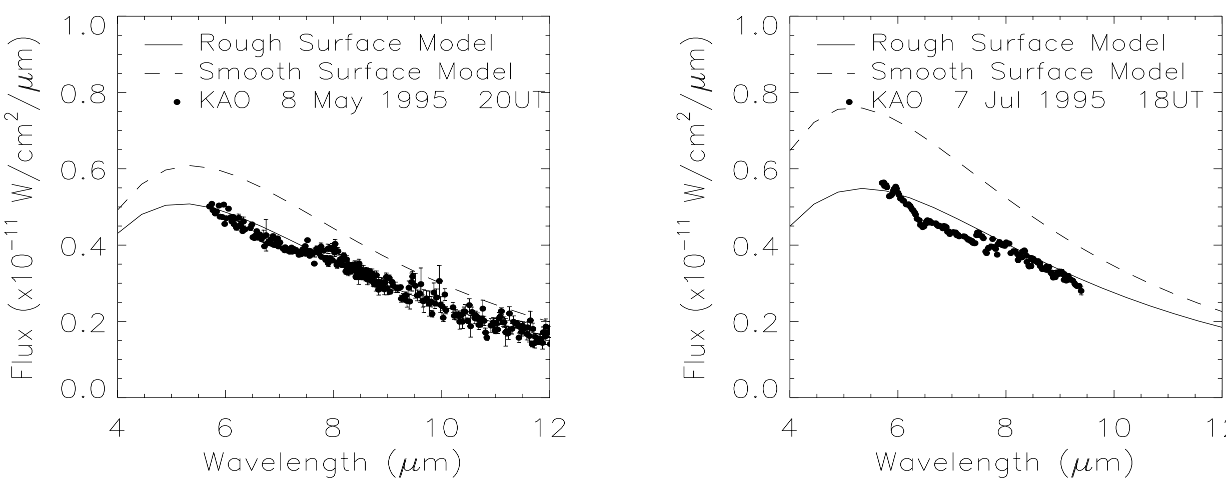


Figure 1. Comparisons of rough surface and smooth surface thermal emission spectra produced by this model for Mercury at four different phase angles. The ratio of thermal emission produced by a rough surface to that produced by a smooth surface is plotted against wavelength. For these calculations Mercury was assumed to have an albedo of 0.119, an emissivity of 1.0, and an RMS surface slope of 30°. Notice that at small phase angles a rough surface emits more radiation than a smooth surface, and at large phase angles a rough surface emits less radiation than a smooth surface.



Figures 2 & 3. Infrared thermal emission spectra of Mercury taken by the Kuiper Airborne Observatory (KAO) on May 8, 1995 and July 7, 1995 respectivly. Also shown are the results of our rough surface thermal emission model and a smooth surface model. The model was run with observational parameters matching the date and time of observations (phase angles of 94.8° and 84.0° respectively) and with an albedo of 0.119 and an emisivity of 1.0. The RMS surface slopes assumed for surface roughness are 25° and 39° respectively. The spectra produced by our rough surface thermal emission model provides a much better fit to the data than do spectra produced by a smooth surface model. Also note that the rough surface model spectra peak at a slightly longer wavelength than the smooth surface spectra.